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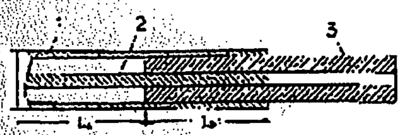
PATENT ABSTRACTS OF JAPAN



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(54) PHASE SHIFTER

(57)Abstract:
PURPOSE: To realize the phase shifter changing continuously a phase of a transmission signal or controlled remotely.
CONSTITUTION: An input terminal of a stub formed by slidably inserting in the axial direction a moving cylinder 3 made of a solid dielectric substance between an outer conductor 1 and an inner conductor 2 from one end of a coaxial line comprising the outer conductor 1 and the inner conductor 2 is connected to a coupling circuit 4 such as a directional coupler, a circulator or a hybrid circuit.

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PATENT ABSTRACTS OF JAPAN

(11)Publication number : 05-121902
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CLAIMS

[Claim(s)]
[Claim 1] The phase shifter characterized by having the stub which inserts in shaft orientations the movable barrel which consists of a solid dielectric possible [sliding] between said outer conductors and inner conductors, and consists of the end of the coaxial track which consists of an outer conductor and an inner conductor.
[Claim 2] The phase shifter according to claim 1 whose stub is an open sand mold stub.
[Claim 3] The phase shifter according to claim 1 whose stub is a short circuit mold stub.
[Claim 4] The phase shifter characterized by having the stub which inserts the movable barrel which consists of a solid dielectric possible [sliding of shaft orientations] between said outer conductors and inner conductors, and consists of the end of the coaxial track which consists of an outer conductor and an inner conductor, and the directional coupler to which the input edge of said stub is connected.
[Claim 5] The phase shifter characterized by having the stub which inserts the movable barrel which consists of a solid dielectric possible [sliding of shaft orientations] between said outer conductors and inner conductors, and consists of the end of the coaxial track which consists of an outer conductor and an inner conductor, and the circulator to which the input edge of said stub is connected.
[Claim 6] The phase shifter characterized by having the stub which inserts the movable barrel which consists of a solid dielectric possible [sliding of shaft orientations] between said outer conductors and inner conductors, and consists of the end of the coaxial track which consists of an outer conductor and an inner conductor, and the hybrid circuit where the input edge of said stub is connected.

[Translation done.]

DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the various electrical and electric equipment in an ultrashort wave thru/or a microwave band, or the phase shifter in an electronic equipment circuit.
[0002]
[Description of the Prior Art] The phase shifter used in order to change the electric supply phase of each component antenna which constitutes the phase shifter conventionally used in the various electrical and electric equipment or electronic equipment circuit in an ultrashort wave thru/or a microwave band, for example, a beam tilt antenna, is constituted so that the four transmission lines with which die length differs mutually may be alternatively inserted in a feeder by the change of a circuit changing switch.
[0003]
[Problem(s) to be Solved by the Invention] In the above-mentioned conventional phase shifter, since the transmission line and two or more circuit changing switches each from which die length differs mutually are needed, a configuration not only becomes intricately large-sized, but it cannot change an electric supply phase continuously.
[0004]
[Means for Solving the Problem] This invention tends to remove the conventional fault by realizing the phase shifter equipped with the stub which inserts the movable barrel which consists of a solid dielectric possible [sliding of shaft orientations] between said outer conductors and inner conductors, and consists of the end of the coaxial track which consists of an outer conductor and an inner conductor, and coupled circuits, such as a directional coupler to which the input edge of said stub is connected, a circulator, or a hybrid circuit.
[0005]
[Function] If the phase angle of the input reflection coefficient in a stub will change if the insertion length of the outer conductor which forms a coaxial track, and the movable barrel which consists of the solid dielectric of a between [inner conductors] is changed, therefore this invention phase shifter is combined with the transmission line, the phase of a transmission signal will change.
[0006]
[Example] the inner conductor of a cartridge are drawing which has a cross section a part and cylindrical [1 / the outer conductor of a cartridge, and 2], or comparatively thin which drawing 1 shows the important section of one example of this invention -- it is -- both -- a coaxial track is formed with a conductor. The profile configuration in the cross section of an outer conductor 1 and an inner conductor 2 can form a square shape or either in circular, can form another side in a square shape, and circular or all can carry out this invention. [each] 3 is the movable barrel which consists of a solid dielectric, and makes the configuration of the periphery edge in the cross section mostly in agreement with the configuration of the inner circumference edge in the cross section of an outer conductor 1. While making mostly in agreement with the configuration of the periphery

edge in the cross section of an inner conductor 2 the configuration of the inner circumference edge in the cross section of the movable barrel 3 which consists of a solid dielectric Thickness of the movable barrel 3 which consists of a solid dielectric is made suitable, and it has formed so that the movable barrel 3 which consists of a solid dielectric can slide freely between an outer conductor 1 and an inner conductor 2 at shaft orientations. 4 is a coupled circuit with an external circuit, for example, consists of a directional coupler, a circulator, or a hybrid circuit. Although not shown in drawing 1 , in the heel of the movable barrel 3 which consists of a solid dielectric, a pulse motor is combined through a rack and a pinion, and the movable barrel 3 which consists of a solid dielectric according to the forward direction of a pulse motor or hard flow rotation is moved forward or retreated, and it constitutes so that the insertion axial length of the movable barrel 3 which consists of the solid dielectric of a between [an outer conductor 1 and inner conductors 2] can be controlled minutely continuously.

[0007] While expressing with LA the axial length of the part between which it is placed by air and expressing [a characteristic impedance] YA and a basic matrix with [FA] for ZA and property admittance, without inserting the movable barrel 3 which consists of a solid dielectric between an outer conductor 1 and an inner conductor 2 If the axial length of the part in which the movable barrel 3 which consists of a solid dielectric is inserted is expressed with LD and YD and a basic matrix are expressed [a characteristic impedance] with [FD] for ZD and property admittance The basic matrix [FAD] of the stub which consists of the movable barrel 3 which consists of an outer conductor 1, an inner conductor 2, and a solid dielectric is expressed with a degree type.

[0008]

[Equation 1]

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$$[F_{AD}] = [F_A]\ [F_D]$$

$$= \begin{bmatrix} \cos m_A L_A & jZ_A \sin m_A L_A \\ jY_A \sin m_A L_A & \cos m_A L_A \end{bmatrix} \begin{bmatrix} \cos m_D L_D & jZ_D \sin m_D L_D \\ jY_D \sin m_D L_D & \cos m_D L_D \end{bmatrix}$$

$$= \begin{bmatrix} \cos m_A L_A \cos m_D L_D - Z_A Y_D \sin m_A L_A \sin m_D L_D & j(Z_D \cos m_A L_A \sin m_D L_D + Z_A \sin m_A L_A \cos m_D L_D) \\ j(Y_A \sin m_A L_A \cos m_D L_D + Y_D \cos m_A L_A \sin m_D L_D) & \cos m_A L_A \cos m_D L_D - Y_A Z_D \sin m_A L_A \sin m_D L_D \end{bmatrix}$$

$$= \begin{bmatrix} A & jB \\ jC & D \end{bmatrix} \qquad \cdots\cdots (1)$$

It sets at a ceremony (1) and is mA=2pi/lambdaAlambdaA. : Guide wave length mD=2 pi/lambdaDlambda D in the part in which the movable barrel 3 which consists of a solid dielectric is not inserted : The guide wave length in the part in which the movable barrel 3 which consists of a solid dielectric is inserted [0009] The complex reflection coefficient gamma at the time of connecting Load ZL to each right end section (it going to drawing 1 and being a right-hand side edge) of the outer conductor 1 which forms a stub, and an inner conductor 2 will be called for by the degree type, if source impedance is set to ZO. [Equation 2]

$$\Gamma = \frac{A Z_L + jB - jC Z_0 Z_L - D Z_0}{A Z_L + jB + jC Z_0 Z_L + D Z_0} \qquad \cdots\cdots (2)$$

Complex reflection coefficient gammaO at the time of opening between each right end section of an outer conductor 1 and an inner conductor 2 wide, when Load ZL is made into infinity It asks by the degree type. It is [Equation 3] when the molecule and denominator of the right-hand side in a formula (2) are broken by ZL.

$$\Gamma = \frac{A + j\dfrac{B}{Z_L} - jC Z_0 - \dfrac{D Z_0}{Z_L}}{A + j\dfrac{B}{Z_L} + jC Z_0 + \dfrac{D Z_0}{Z_L}}$$

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It is [Equation 4] when ZL of an upper type is made into infinity.

$$\Gamma_0 = \frac{A - jC\, Z_0}{A + jC\, Z_0} \quad \cdots\cdots (3)$$

Complex reflection coefficient gammaO Phase angle thetaO It is expressed with a degree type.

[Equation 5]

$$\begin{aligned}\theta_0 &= \arg\left(\frac{A - jC\, Z_0}{A + jC\, Z_0}\right) \\ &= \arg(A - jC\, Z_0) - \arg(A + jC\, Z_0) \\ &= 2\tan^{-1}\left(\frac{-C\, Z_0}{A}\right) \quad \cdots\cdots (4)\end{aligned}$$

If the insertion length LD of the movable barrel 3 which consists of a solid dielectric is changed so that clearly from each above-mentioned formula, it is complex reflection coefficient gammaO. An absolute value is 1 and is phase angle thetaO. It can accept and change. That is, only the phase of a reflected wave can be changed, without being accompanied by reflection loss.

[0010] For drawing 2 , a directional coupler, for example, the phase contrast between outputs, is 90 degrees about the coupled circuit 4 shown in drawing 1 , and degree of coupling is about 3dB. It is drawing for explaining the electrical characteristics of the coupled circuit 4 at the time of constituting from a directional coupler, it sets to drawing 2 , and is DCP. For a directional coupler and T1, an input terminal and T2 are [a joint terminal and T four of a direct terminal and T3] isolation terminals. Directional coupler DCP It is thetaC about the electrical angle of CC and the joint track section in an electrical-potential-difference coupling coefficient. When it carries out, the scattering matrix [S] of this directional coupler is expressed with a degree type.

[0011]

[Equation 6

$$[S]=\begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$$

$$=\begin{bmatrix} 0 & \frac{jC_c\sin\theta_c}{D_c} & \frac{\sqrt{1-C_c^2}}{D_c} & 0 \\ \frac{jC_c\sin\theta_c}{D_c} & 0 & 0 & \frac{\sqrt{1-C_c^2}}{D_c} \\ \frac{\sqrt{1-C_c^2}}{D_c} & 0 & 0 & \frac{jC_c\sin\theta_c}{D_c} \\ 0 & \frac{\sqrt{1-C_c^2}}{D_c} & \frac{jC_c\sin\theta_c}{D_c} & 0 \end{bmatrix} \quad \cdots\cdots (5)$$

It sets at a ceremony (5) and is [Equation 7].

$$D_c=\sqrt{1-C_c^2}\ \cos\theta_c\ +j\sin\theta_c$$

[0012] Each output voltage EO1 and EO2 of the terminal T1 at the time of impressing input voltage Ei to a terminal T1 thru/or T four, and EO3 And EO4 It asks by the degree type.

[Equation 8]

$$\begin{bmatrix} E_{o1} \\ E_{o2} \\ E_{o3} \\ E_{o4} \end{bmatrix} = \begin{bmatrix} 0 & \frac{jC_c\sin\theta_c}{D_c} & \frac{\sqrt{1-C_c^2}}{D_c} & 0 \\ \frac{jC_c\sin\theta_c}{D_c} & 0 & 0 & \frac{\sqrt{1-C_c^2}}{D_c} \\ \frac{\sqrt{1-C_c^2}}{D_c} & 0 & 0 & \frac{jC_c\sin\theta_c}{D_c} \\ 0 & \frac{\sqrt{1-C_c^2}}{D_c} & \frac{jC_c\sin\theta_c}{D_c} & 0 \end{bmatrix} \begin{bmatrix} E_i \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ \frac{jC_c\sin\theta_c}{D_c}E_i \\ \frac{\sqrt{1-C_c^2}}{D_c}E_i \\ 0 \end{bmatrix} \quad \cdots\cdots (6)$$

[0013] Drawing 3 is a representative circuit schematic at the time of constituting the representative circuit schematic 4 of drawing 1 , i.e., the coupled circuit of drawing 1 , from a directional coupler explaining drawing 2 , and is STB. It is the stub which consists of the movable barrel 3 which consists of the outer conductor 1 in drawing 1 , an inner conductor 2, and a solid dielectric, and other signs are the same as that of drawing 2 . Directional coupler DCP Reflector voltage E2R shown in a degree type at a terminal T2 and T3 when input voltage Ei is impressed to a terminal T1 And E3R It appears.

[Equation 9]

$$E_{2R} = \frac{jC_c\sin\theta_c}{D_c}\Gamma_0 E_i \quad \cdots\cdots (7)$$

$$E_{2R} = \frac{\sqrt{1-C_c^2}}{D_c}\Gamma_0 E_i \quad \cdots\cdots (8)$$

[0014] therefore, the terminal T1 at the time of impressing input voltage Ei to a terminal T1 thru/or T four -- each -- output voltage EO1S, EO2S, EO3S, and EO4S are calculated by the degree type.

[Equation 10]

$$\begin{bmatrix} E_{O1S} \\ E_{O2S} \\ E_{O3S} \\ E_{O4S} \end{bmatrix} = \begin{bmatrix} 0 & \frac{jC_c \sin\theta_c}{D_c} & \frac{\sqrt{1-C_c^2}}{D_c} & 0 \\ \frac{jC_c \sin\theta_c}{D_c} & 0 & 0 & \frac{\sqrt{1-C_c^2}}{D_c} \\ \frac{\sqrt{1-C_c^2}}{D_c} & 0 & 0 & \frac{jC_c \sin\theta_c}{D_c} \\ 0 & \frac{\sqrt{1-C_c^2}}{D_c} & \frac{jC_c \sin\theta_c}{D_c} & 0 \end{bmatrix} \begin{bmatrix} 0 \\ E_{2R} \\ E_{3R} \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{\sqrt{1-C_c^2}\, E_{3R} + jC_c \sin\theta_c\, E_{2R}}{D_c} \\ 0 \\ 0 \\ \frac{\sqrt{1-C_c^2}\, E_{2R} + jC_c \sin\theta_c\, E_{3R}}{D_c} \end{bmatrix} \quad \cdots\cdots (9)$$

[0015] Output voltage EO1S of a terminal T1 and T four and EO4S are calculated from a formula (7), a formula (8), and a formula (9), and it is a directional coupler DCP. It is [Equation 11] about the electrical-potential-difference coupling coefficient CC.

$$C_c = \frac{1}{\sqrt{2}}$$

While placing, it is a directional coupler DCP. Electrical angle thetaC of the joint track section which can be set It considers as 90 degrees, and when the formula showing output voltage EO1S and EO4S is arranged, output voltage EO1S and EO4S are expressed with a degree type.

[Equation 12]

$$|E_{01s}| = \left| \frac{(1-C_c^2) - C_c^2 \sin^2\theta_c}{D_c^2} \hat{E}_1 \Gamma_0 \right| = 0 \quad \cdots\cdots (10)$$

$$|E_{04s}| = \left| \frac{j2\sqrt{(1-C_c^2)}\, C_c \sin\theta_c}{D_c^2} E_1 \Gamma_0 \right| = | E_1 \Gamma_0 | \quad \cdots\cdots (11)$$

namely, -- without the electrical potential difference applied to the terminal T1 (or T four) is accompanied by loss -- a phase -- thetaO only -- it changes, and appears in terminal T four (or T1), and reflector voltage does not appear in a terminal T1 (or T four)
[0016] the movable barrel to which the sectional view (X-X sectional view of drawing 5) in which drawing 4 shows the important section of other examples of this invention, and drawing 5 are rear view, an outer conductor and 2 change from an inner conductor, and 3 changes from a solid dielectric in 1 in both drawings, and 4 -- a coupled circuit and 5 -- a short circuit -- it is a conductor and between each heel of an outer conductor 1 and an inner conductor 2 is short-circuited electrically. the short circuit among the side attachment walls of the movable barrel 3 which 6 is infeed and consists of a solid dielectric -- while continuing and preparing axial length suitably from the heel of the side-attachment-wall part corresponding to the part in which the conductor 5 was formed -- the width of face of infeed 6 -- a short circuit -- it compares with the width of face of a conductor 5, and is suitably made size. the infeed 6 prepared in the side attachment wall of the movable barrel 3 which a short circuit mold stub is formed of the movable barrel 3 which consists of an outer conductor 1, an inner conductor 2, and a solid dielectric, and consists of a solid dielectric by it in this example -- a short circuit -- while corresponding to the location of a conductor 5 -- the width of face of infeed 6 -- a short circuit -- there is no possibility that sliding to the shaft orientations of the movable barrel 3 which compares with the width of face of a conductor 5, and consists of a solid dielectric since it is size suitably may be checked. Also in this example, it is the same as that of the example before preparing the driver element of shaft orientations in the heel of the movable barrel 3 which consists of a solid dielectric.
[0017] The load ZL in a formula (2) since the stub in this example is a short circuit mold stub is zero, therefore is complex reflection coefficient gammaS in this case. And complex reflection coefficient gammaS Phase angle thetaS It is expressed with a degree type, respectively.

[Equation 13]

$$|E_{01S}| = \left| \frac{(1-C_c^2) - C_c^2 \sin^2\theta_c}{D_c^2} E_i \Gamma_0 \right| = 0 \quad \cdots\cdots (10)$$

$$|E_{04S}| = \left| \frac{j2\sqrt{(1-C_c^2)}\, C_c \sin\theta_c}{D_c^2} E_i \Gamma_0 \right| = | E_i \Gamma_0 | \quad \cdots\cdots (11)$$

Complex reflection coefficient gammaO [in / on this example and / a formula (10) and a formula (11)] gammaS By replacing, output voltage EO1S and EO4S can be calculated.
[0018] Drawing 6 is the insertion length of the movable barrel 3 and complex reflection coefficient gammaO which consist of the solid dielectric in each example shown in drawing 1 , drawing 4 , and drawing 5 . The insertion length and complex reflection coefficient gammaS of the movable barrel 3 which consist of an example and the solid dielectric of relation with phase angle thetaO Phase angle thetaS An example of relation the insertion length LD (mm) and axis of ordinate of the movable barrel 3 to which it is the curvilinear Fig. shown based on theoretical calculated value, respectively, and an axis of abscissa changes from a solid dielectric -- phase angle thetaO Or thetaS (deg) it is . Phase angle thetaO Curve and phase angle thetaS which shows change The specific inductive capacity of the movable barrel 3 to which any curve of the curve which shows change changes 400mm and a characteristic impedance ZA from 50 ohms and a solid dielectric in each axial length of an outer conductor 1 and an inner conductor 2 is asked for 2.3 and an operating frequency as 750MHz.
[0019] Drawing 7 is also the representative circuit schematic of other examples of this invention, i.e., the example which formed the coupled circuit 4 in drawing 1 by the circulator, and is CCL. A circulator and STB It is the open sand mold stub same with having explained drawing 1 . circulator CCL Input terminal TC 1 the applied electrical potential difference -- output terminal TC 2 from -- open sand mold stub STB it adds -- having -- open sand mold stub STB the reflected wave which can be set -- terminal TC 2 minding -- circulator CCL it adds -- having -- isolation terminal TC 3 from -- it is outputted. terminal TC 3 from -- without the electrical potential difference outputted is accompanied by loss -- a phase -- complex reflection coefficient gammaO Phase angle thetaO only -- it is the same as that of the example shown in changing drawing 1 . open sand mold stub STB in drawing 7 this invention can be carried out even if it transposes to the short circuit mold stub explaining drawing 4 and drawing 5 -- it is natural.
[0020] The above coupled circuits are used as a coupled circuit 4 in drawing 1 , and also they are the TEM transmission line or semi- TEM, for example. The directional coupler

or TEM formed in the transmission line The transmission line or semi- TEM The hybrid circuit formed in the transmission line may be used. Moreover, although the above explained the case where it constituted so that the movable barrel 3 which consists of a solid dielectric by the rack, the pinion, and the pulse motor may be driven to shaft orientations, you may make it drive in hand control.

[0021]

[Effect of the Invention] this invention phase shifter has a comparatively brief configuration, and can change the phase of input voltage continuously, and has the features that the drive of the movable barrel 3 which consists of a solid dielectric is controllable from a remote place point etc., they are used for it as a phase shifter in various electrical and electric equipment or an electronic equipment circuit, and it is ****** -- it is size.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] This invention relates to the various electrical and electric equipment in an ultrashort wave thru/or a microwave band, or the phase shifter in an electronic equipment circuit.

[Translation done.]

PRIOR ART

[Description of the Prior Art] The phase shifter used in order to change the electric supply phase of each component antenna which constitutes the phase shifter conventionally used in the various electrical and electric equipment or electronic equipment circuit in an ultrashort wave thru/or a microwave band, for example, a beam tilt antenna, is constituted so that the four transmission lines with which die length differs

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mutually may be alternatively inserted in a feeder by the change of a circuit changing switch.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] this invention phase shifter has a comparatively brief configuration, and can change the phase of input voltage continuously, and has the features that the drive of the movable barrel 3 which consists of a solid dielectric is controllable from a remote place point etc., they are used for it as a phase shifter in various electrical and electric equipment or an electronic equipment circuit, and it is ****** -- it is size.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] In the above-mentioned conventional phase shifter, since the transmission line and two or more circuit changing switches each from which die length differs mutually are needed, a configuration not only becomes intricately large-sized, but it cannot change an electric supply phase continuously.

[Translation done.]

MEANS

[Means for Solving the Problem] This invention tends to remove the conventional fault by realizing the phase shifter equipped with the stub which inserts the movable barrel which consists of a solid dielectric possible [sliding of shaft orientations] between said outer conductors and inner conductors, and consists of the end of the coaxial track which consists of an outer conductor and an inner conductor, and coupled circuits, such as a directional coupler to which the input edge of said stub is connected, a circulator, or a

hybrid circuit.

[Translation done.]

OPERATION

[Function] If the phase angle of the input reflection coefficient in a stub will change if the insertion length of the outer conductor which forms a coaxial track, and the movable barrel which consists of the solid dielectric of a between [inner conductors] is changed, therefore this invention phase shifter is combined with the transmission line, the phase of a transmission signal will change.

[Translation done.]

EXAMPLE

[Example] the inner conductor of a cartridge are drawing which has a cross section a part and cylindrical [1 / the outer conductor of a cartridge, and 2], or comparatively thin which drawing 1 shows the important section of one example of this invention -- it is -- both -- a coaxial track is formed with a conductor. The profile configuration in the cross section of an outer conductor 1 and an inner conductor 2 can form a square shape or either in circular, can form another side in a square shape, and circular or all can carry out this invention. [each] 3 is the movable barrel which consists of a solid dielectric, and makes the configuration of the periphery edge in the cross section mostly in agreement with the configuration of the inner circumference edge in the cross section of an outer conductor 1. While making mostly in agreement with the configuration of the periphery edge in the cross section of an inner conductor 2 the configuration of the inner circumference edge in the cross section of the movable barrel 3 which consists of a solid dielectric Thickness of the movable barrel 3 which consists of a solid dielectric is made suitable, and it has formed so that the movable barrel 3 which consists of a solid dielectric can slide freely between an outer conductor 1 and an inner conductor 2 at shaft orientations. 4 is a coupled circuit with an external circuit, for example, consists of a directional coupler, a circulator, or a hybrid circuit. Although not shown in drawing 1 , in the heel of the movable barrel 3 which consists of a solid dielectric, a pulse motor is combined through a rack and a pinion, and the movable barrel 3 which consists of a solid dielectric according to the forward direction of a pulse motor or hard flow rotation is moved forward or retreated, and it constitutes so that the insertion axial length of the

movable barrel 3 which consists of the solid dielectric of a between [an outer conductor 1 and inner conductors 2] can be controlled minutely continuously.
[0007] While expressing with LA the axial length of the part between which it is placed by air and expressing [a characteristic impedance] YA and a basic matrix with [FA] for ZA and property admittance, without inserting the movable barrel 3 which consists of a solid dielectric between an outer conductor 1 and an inner conductor 2 If the axial length of the part in which the movable barrel 3 which consists of a solid dielectric is inserted is expressed with LD and YD and a basic matrix are expressed [a characteristic impedance] with [FD] for ZD and property admittance The basic matrix [FAD] of the stub which consists of the movable barrel 3 which consists of an outer conductor 1, an inner conductor 2, and a solid dielectric is expressed with a degree type.
[0008]

[Equation 1]

$$[F_{AD}] = [F_A]\ [F_D]$$

$$= \begin{bmatrix} \cos m_A L_A & jZ_A \sin m_A L_A \\ jY_A \sin m_A L_A & \cos m_A L_A \end{bmatrix} \begin{bmatrix} \cos m_D L_D & jZ_D \sin m_D L_D \\ jY_D \sin m_D L_D & \cos m_D L_D \end{bmatrix}$$

$$= \begin{bmatrix} \cos m_A L_A \cos m_D L_D - Z_A Y_D \sin m_A L_A \sin m_D L_D & j(Z_D \cos m_A L_A \sin m_D L_D + Z_A \sin m_A L_A \cos m_D L_D) \\ j(Y_A \sin m_A L_A \cos m_D L_D + Y_D \cos m_A L_A \sin m_D L_D) & \cos m_A L_A \cos m_D L_D - Y_A Z_D \sin m_A L_A \sin m_D L_D \end{bmatrix}$$

$$= \begin{bmatrix} A & jB \\ jC & D \end{bmatrix} \qquad \cdots\cdots (1)$$

It sets at a ceremony (1) and is mA=2pi/lambdaAlambdaA. : Guide wave length mD=2 pi/lambdaDlambda D in the part in which the movable barrel 3 which consists of a solid dielectric is not inserted : The guide wave length in the part in which the movable barrel 3 which consists of a solid dielectric is inserted [0009] The complex reflection coefficient gamma at the time of connecting Load ZL to each right end section (it going to drawing 1 and being a right-hand side edge) of the outer conductor 1 which forms a stub, and an inner conductor 2 will be called for by the degree type, if source impedance is set to ZO.
[Equation 2]

$$\Gamma = \frac{A\ Z_L + jB - jC\ Z_0\ Z_L - D\ Z_0}{A\ Z_L + jB + jC\ Z_0\ Z_L + D\ Z_0} \qquad \cdots\cdots (2)$$

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Complex reflection coefficient gammaO at the time of opening between each right end section of an outer conductor 1 and an inner conductor 2 wide, when Load ZL is made into infinity It asks by the degree type. It is [Equation 3] when the molecule and denominator of the right-hand side in a formula (2) are broken by ZL.

$$\Gamma = \frac{A + j\frac{B}{Z_L} - jC\,Z_0 - \frac{D\,Z_0}{Z_L}}{A + j\frac{B}{Z_L} + jC\,Z_0 + \frac{D\,Z_0}{Z_L}}$$

It is [Equation 4] when ZL of an upper type is made into infinity.

$$\Gamma_0 = \frac{A - jC\,Z_0}{A + jC\,Z_0} \qquad \cdots\cdots (3)$$

Complex reflection coefficient gammaO Phase angle thetaO It is expressed with a degree type.

[Equation 5]

$$\begin{aligned}\theta_0 &= \arg\left(\frac{A - jC\,Z_0}{A + jC\,Z_0}\right)\\ &= \arg(A - jC\,Z_0) - \arg(A + jC\,Z_0)\\ &= 2\tan^{-1}\left(\frac{-C\,Z_0}{A}\right) \qquad \cdots\cdots (4)\end{aligned}$$

If the insertion length LD of the movable barrel 3 which consists of a solid dielectric is changed so that clearly from each above-mentioned formula, it is complex reflection coefficient gammaO. An absolute value is 1 and is phase angle thetaO. It can accept and change. That is, only the phase of a reflected wave can be changed, without being accompanied by reflection loss.

[0010] For drawing 2 , a directional coupler, for example, the phase contrast between outputs, is 90 degrees about the coupled circuit 4 shown in drawing 1 , and degree of coupling is about 3dB. It is drawing for explaining the electrical characteristics of the coupled circuit 4 at the time of constituting from a directional coupler, it sets to drawing 2 , and is DCP. For a directional coupler and T1, an input terminal and T2 are [a joint terminal and T four of a direct terminal and T3] isolation terminals. Directional coupler

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DCP It is thetaC about the electrical angle of CC and the joint track section in an electrical-potential-difference coupling coefficient. When it carries out, the scattering matrix [S] of this directional coupler is expressed with a degree type.
[0011]

[Equation 6]

$$[S]=\begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$$

$$=\begin{bmatrix} 0 & \frac{jC_c \sin\theta_c}{D_c} & \frac{\sqrt{1-C_c^2}}{D_c} & 0 \\ \frac{jC_c \sin\theta_c}{D_c} & 0 & 0 & \frac{\sqrt{1-C_c^2}}{D_c} \\ \frac{\sqrt{1-C_c^2}}{D_c} & 0 & 0 & \frac{jC_c \sin\theta_c}{D_c} \\ 0 & \frac{\sqrt{1-C_c^2}}{D_c} & \frac{jC_c \sin\theta_c}{D_c} & 0 \end{bmatrix} \quad \cdots\cdots (5)$$

It sets at a ceremony (5) and is [Equation 7].

$$D_c=\sqrt{1-C_c^2}\cos\theta_c+j\sin\theta_c$$

[0012] Each output voltage EO1 and EO2 of the terminal T1 at the time of impressing input voltage Ei to a terminal T1 thru/or T four, and EO3 And EO4 It asks by the degree type.

[Equation 8]

$$\begin{bmatrix} E_{O1} \\ E_{O2} \\ E_{O3} \\ E_{O4} \end{bmatrix} = \begin{bmatrix} 0 & \frac{jC_C \sin\theta_C}{D_C} & \frac{\sqrt{1-C_C^2}}{D_C} & 0 \\ \frac{jC_C \sin\theta_C}{D_C} & 0 & 0 & \frac{\sqrt{1-C_C^2}}{D_C} \\ \frac{\sqrt{1-C_C^2}}{D_C} & 0 & 0 & \frac{jC_C \sin\theta_C}{D_C} \\ 0 & \frac{\sqrt{1-C_C^2}}{D_C} & \frac{jC_C \sin\theta_C}{D_C} & 0 \end{bmatrix} \begin{bmatrix} E_I \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ \frac{jC_C \sin\theta_C}{D_C} E_I \\ \frac{\sqrt{1-C_C^2}}{D_C} E_I \\ 0 \end{bmatrix} \qquad \cdots\cdots (6)$$

[0013] Drawing 3 is a representative circuit schematic at the time of constituting the representative circuit schematic 4 of drawing 1 , i.e., the coupled circuit of drawing 1 , from a directional coupler explaining drawing 2 , and is STB. It is the stub which consists of the movable barrel 3 which consists of the outer conductor 1 in drawing 1 , an inner conductor 2, and a solid dielectric, and other signs are the same as that of drawing 2 . Directional coupler DCP Reflector voltage E2R shown in a degree type at a terminal T2 and T3 when input voltage Ei is impressed to a terminal T1 And E3R It appears.

[Equation 9]

$$E_{2R} = \frac{jC_C \sin\theta_C}{D_C} \Gamma_O E_I \qquad \cdots\cdots (7)$$

$$E_{2R} = \frac{\sqrt{1-C_C^2}}{D_C} \Gamma_O E_I \qquad \cdots\cdots (8)$$

[0014] therefore, the terminal T1 at the time of impressing input voltage Ei to a terminal T1 thru/or T four -- each -- output voltage EO1S, EO2S, EO3S, and EO4S are calculated by the degree type.

[Equation 10]

$$\begin{bmatrix} E_{O1S} \\ E_{O2S} \\ E_{O3S} \\ E_{O4S} \end{bmatrix} = \begin{bmatrix} 0 & \frac{jC_C \sin\theta_C}{D_C} & \frac{\sqrt{1-C_C^2}}{D_C} & 0 \\ \frac{jC_C \sin\theta_C}{D_C} & 0 & 0 & \frac{\sqrt{1-C_C^2}}{D_C} \\ \frac{\sqrt{1-C_C^2}}{D_C} & 0 & 0 & \frac{jC_C \sin\theta_C}{D_C} \\ 0 & \frac{\sqrt{1-C_C^2}}{D_C} & \frac{jC_C \sin\theta_C}{D_C} & 0 \end{bmatrix} \begin{bmatrix} 0 \\ E_{2R} \\ E_{3R} \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{\sqrt{1-C_C^2}\ E_{3R} + jC_C \sin\theta_C\ E_{2R}}{D_C} \\ 0 \\ 0 \\ \frac{\sqrt{1-C_C^2}\ E_{2R} + jC_C \sin\theta_C\ E_{3R}}{D_C} \end{bmatrix} \quad \cdots\cdots (9)$$

[0015] Output voltage EO1S of a terminal T1 and T four and EO4S are calculated from a formula (7), a formula (8), and a formula (9), and it is a directional coupler DCP. It is [Equation 11] about the electrical-potential-difference coupling coefficient CC.

$$C_C = \frac{1}{\sqrt{2}}$$

While placing, it is a directional coupler DCP. Electrical angle thetaC of the joint track section which can be set It considers as 90 degrees, and when the formula showing output voltage EO1S and EO4S is arranged, output voltage EO1S and EO4S are expressed with a degree type.

[Equation 12]

$$|E_{013}| = \left| \frac{(1 - C_c^2) - C_c^2 \sin^2\theta_c}{D_c^2} E_I \Gamma_0 \right| = 0 \quad \cdots\cdots (10)$$

$$|E_{043}| = \left| \frac{j2\sqrt{(1 - C_c^2)}\, C_c \sin\theta_c}{D_c^2} E_I \Gamma_0 \right| = |E_I \Gamma_0| \quad \cdots\cdots (11)$$

namely, -- without the electrical potential difference applied to the terminal T1 (or T four) is accompanied by loss -- a phase -- thetaO only -- it changes, and appears in terminal T four (or T1), and reflector voltage does not appear in a terminal T1 (or T four)
[0016] the movable barrel to which the sectional view (X-X sectional view of drawing 5) in which drawing 4 shows the important section of other examples of this invention, and drawing 5 are rear view, an outer conductor and 2 change from an inner conductor, and 3 changes from a solid dielectric in 1 in both drawings, and 4 -- a coupled circuit and 5 -- a short circuit -- it is a conductor and between each heel of an outer conductor 1 and an inner conductor 2 is short-circuited electrically. the short circuit among the side attachment walls of the movable barrel 3 which 6 is infeed and consists of a solid dielectric -- while continuing and preparing axial length suitably from the heel of the side-attachment-wall part corresponding to the part in which the conductor 5 was formed -- the width of face of infeed 6 -- a short circuit -- it compares with the width of face of a conductor 5, and is suitably made size. the infeed 6 prepared in the side attachment wall of the movable barrel 3 which a short circuit mold stub is formed of the movable barrel 3 which consists of an outer conductor 1, an inner conductor 2, and a solid dielectric, and consists of a solid dielectric by it in this example -- a short circuit -- while corresponding to the location of a conductor 5 -- the width of face of infeed 6 -- a short circuit -- there is no possibility that sliding to the shaft orientations of the movable barrel 3 which compares with the width of face of a conductor 5, and consists of a solid dielectric since it is size suitably may be checked. Also in this example, it is the same as that of the example before preparing the driver element of shaft orientations in the heel of the movable barrel 3 which consists of a solid dielectric.
[0017] The load ZL in a formula (2) since the stub in this example is a short circuit mold stub is zero, therefore is complex reflection coefficient gammaS in this case. And complex reflection coefficient gammaS Phase angle thetaS It is expressed with a degree type, respectively.

[Equation 13]

$$\Gamma_S = \frac{jB - D\,Z_0}{jB + D\,Z_0} = -\frac{D\,Z_0 - jB}{D\,Z_0 + jB} \qquad \cdots\cdots (12)$$

$$\begin{aligned}\theta_S &= \arg\left(\frac{-D\,Z_0 + jB}{D\,Z_0 + jB}\right) \\ &= 180^\circ + \arg\left(\frac{D\,Z_0 - jB}{D\,Z_0 + jB}\right) \\ &= 180^\circ + \arg(D\,Z_0 - jB) - \arg(D\,Z_0 + jB) \\ &= 180^\circ + 2\tan^{-1}\left(\frac{-B}{D\,Z_0}\right) \qquad \cdots\cdots (13)\end{aligned}$$

Complex reflection coefficient gammaO [in / on this example and / a formula (10) and a formula (11)] gammaS By replacing, output voltage EO1S and EO4S can be calculated.
[0018] Drawing 6 is the insertion length of the movable barrel 3 and complex reflection coefficient gammaO which consist of the solid dielectric in each example shown in drawing 1 , drawing 4 , and drawing 5 . The insertion length and complex reflection coefficient gammaS of the movable barrel 3 which consist of an example and the solid dielectric of relation with phase angle thetaO Phase angle thetaS An example of relation the insertion length LD (mm) and axis of ordinate of the movable barrel 3 to which it is the curvilinear Fig. shown based on theoretical calculated value, respectively, and an axis of abscissa changes from a solid dielectric -- phase angle thetaO Or thetaS (deg) it is . Phase angle thetaO Curve and phase angle thetaS which shows change The specific inductive capacity of the movable barrel 3 to which any curve of the curve which shows change changes 400mm and a characteristic impedance ZA from 50 ohms and a solid dielectric in each axial length of an outer conductor 1 and an inner conductor 2 is asked for 2.3 and an operating frequency as 750MHz.
[0019] Drawing 7 is also the representative circuit schematic of other examples of this invention, i.e., the example which formed the coupled circuit 4 in drawing 1 by the circulator, and is CCL. A circulator and STB It is the open sand mold stub same with having explained drawing 1 . circulator CCL Input terminal TC 1 the applied electrical potential difference -- output terminal TC 2 from -- open sand mold stub STB it adds -- having -- open sand mold stub STB the reflected wave which can be set -- terminal TC 2 minding -- circulator CCL it adds -- having -- isolation terminal TC 3 from -- it is outputted. terminal TC 3 from -- without the electrical potential difference outputted is accompanied by loss -- a phase -- complex reflection coefficient gammaO Phase angle thetaO only -- it is the same as that of the example shown in changing drawing 1 . open sand mold stub STB in drawing 7 this invention can be carried out even if it transposes to the short circuit mold stub explaining drawing 4 and drawing 5 -- it is natural.
[0020] The above coupled circuits are used as a coupled circuit 4 in drawing 1 , and also they are the TEM transmission line or semi- TEM, for example. The directional coupler

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or TEM formed in the transmission line The transmission line or semi- TEM The hybrid circuit formed in the transmission line may be used. Moreover, although the above explained the case where it constituted so that the movable barrel 3 which consists of a solid dielectric by the rack, the pinion, and the pulse motor may be driven to shaft orientations, you may make it drive in hand control.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the important section of one example of this invention which has a cross section in part.
[Drawing 2] It is drawing for explaining an example of the property of the coupled circuit in this invention phase shifter.
[Drawing 3] It is the representative circuit schematic of this invention phase shifter.
[Drawing 4] It is drawing showing the important section of other examples of this invention which has a cross section in part.
[Drawing 5] It is the rear view showing the important section of other examples of this invention.
[Drawing 6] It is the curvilinear Fig. showing an example of the property of this invention phase shifter.
[Drawing 7] It is the representative circuit schematic showing other examples of this invention.
[Description of Notations]
1 Outer Conductor
2 Inner Conductor
3 Movable Barrel Which Consists of Solid Dielectric
4 Coupled Circuit
DCP Directional coupler
T1 Input terminal
T2 Direct terminal
T3 Joint terminal
T four Isolation terminal
STB Stub
5 Short Circuit -- Conductor
6 Infeed
CCL Circulator
TC1 Input terminal

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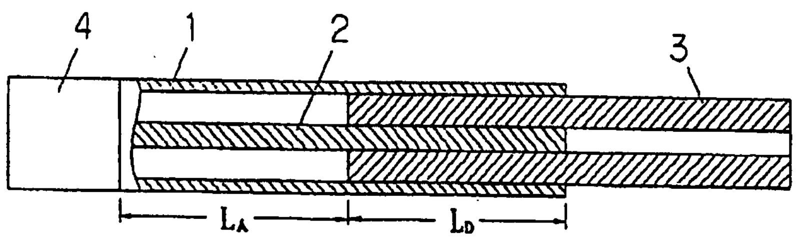
TC2 Output terminal
TC3 Isolation terminal

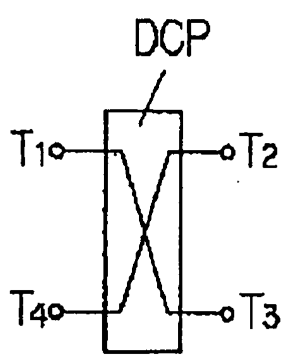
[Translation done.]

DRAWINGS

[Drawing 1]



[Drawing 2]



[Drawing 3]

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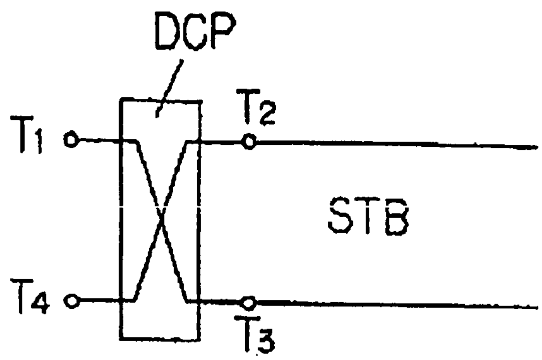
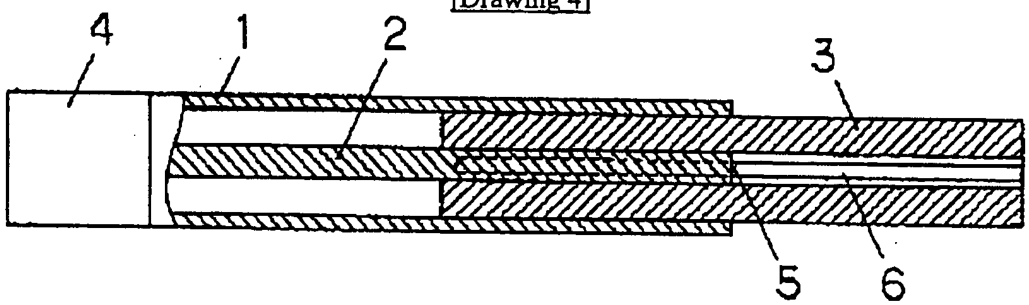
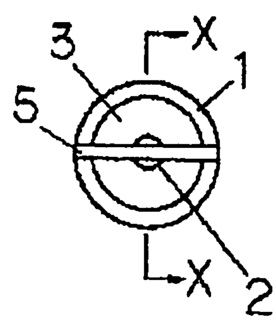


[Drawing 4]



[Drawing 5]



[Drawing 6]

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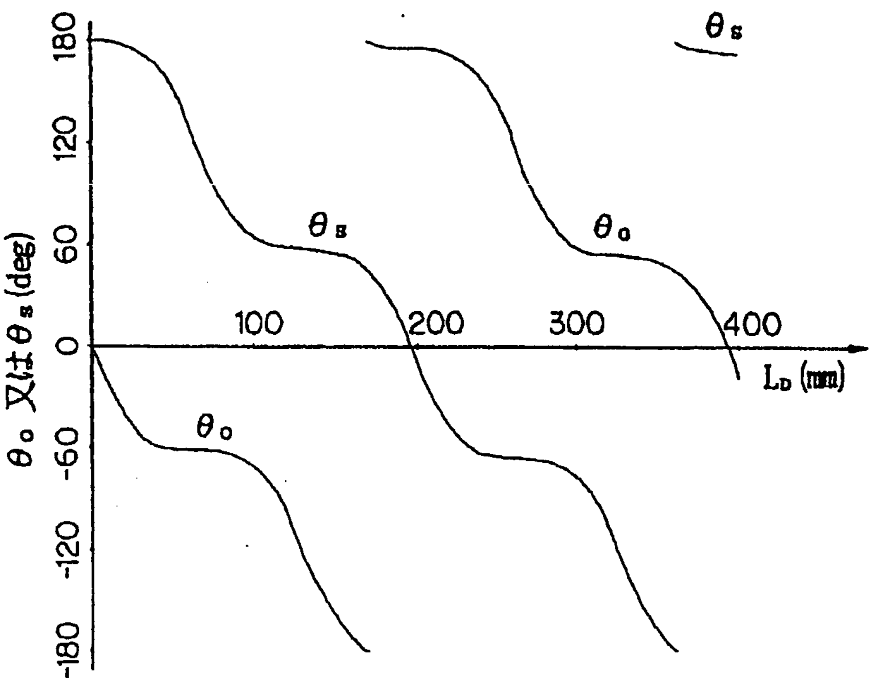
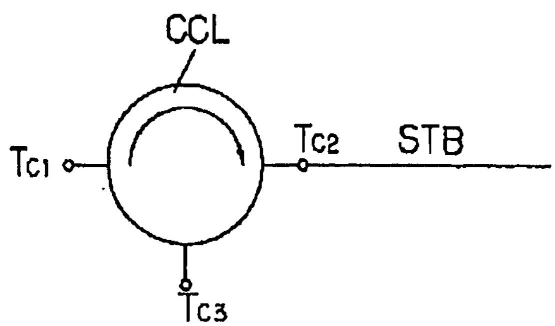


[Drawing 7]



[Translation done.]